

Evaluation of Apical Seal between Single Cone and Cold Lateral Condensation Techniques after Post Space Preparation at Different Timing

(Penilaian Pengapan Apeks antara Teknik Satu Kon dan Pemasangan Lateral Sejuk Selepas Penyediaan Ruang Tiang pada Masa yang Berlainan)

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ABSTRACT

Obturation technique may have an effect on the apical seal following post space preparation. This study aimed to evaluate the apical seal of single cone and cold lateral condensation obturation techniques after post space preparation at two different timing. A total of 120 decoronated, single-rooted human premolars were divided into two groups (n=50) based on canal preparation and obturation techniques; group A - hand ProTaper/ single cone and group B - modified double-flared/ cold lateral condensation. Each group was then subdivided into two subgroups (n=25) (subgroup I- post space preparation immediately after obturation; subgroup II- post space preparation 7 days later). The remaining 20 teeth served as positive and negative controls. The external root surface was coated with nail varnish, submerged in 2% methylene-blue dye and incubated at 37°C for 72 h. Each tooth was later sectioned apico-coronally at 1 mm interval and evaluated using dissecting microscope. The results revealed that obturation techniques do not affect the apical seal ($p>0.05$). Immediate post preparation groups achieved significantly better seal for both obturation techniques when compared with the delayed groups at the level 3 mm and above from the apex ($p<0.05$). Immediate post space preparation provides better apical seal regardless of obturation techniques used.

Keywords: Apical seal; cold lateral condensation; post space preparation; single cone

ABSTRAK

Teknik pengobturatan mungkin mempunyai kesan ke atas pengapan apeks selepas penyediaan ruang tiang. Kajian ini dijalankan bertujuan untuk menilai pengapan apikal antara teknik pengobturatan satu kon dan teknik pemasangan lateral sejuk selepas penyediaan ruang tiang pada dua masa yang berlainan. Sebanyak 120 gigi pramolar manusia yang telah dipotong bahagian korona dibahagikan kepada 2 kumpulan secara rawak (n=50) mengikut teknik penyediaan kanal dan teknik pengobturatan iaitu kumpulan A- menggunakan sistem ProTaper tangan/pengobturatan satu kon dan kumpulan B - menggunakan teknik penyediaan cakahan berkembar terubahsuai/ teknik pemasangan lateral sejuk. Setiap kumpulan seterusnya dibahagikan kepada 2 sub-kumpulan (n=25) iaitu sub-kumpulan 1- penyediaan ruang tiang sejurus selepas pengobturatan dan sub- kumpulan 2- penyediaan ruang tiang 7 hari selepas pengobturatan. Gigi yang selebihnya (n=20) digunakan sebagai kumpulan kawalan positif dan negatif. Permukaan luar akar gigi disalutkan dengan varnis kuku 1 mm daripada foramen apikal, direndam sepenuhnya di dalam 2% larutan pewarna metilene biru dan diinkubasi pada 37°C selama 72 jam. Setiap gigi kemudiannya dipotong dari arah apikal-korona setebal 1 mm setiap satu dan dilihat di bawah mikroskop diseksi. Pemerhatian menunjukkan teknik pengobturatan tidak mempengaruhi pengapan apeks ($p>0.05$). Penyediaan ruang tiang sejurus selepas pengobturatan menunjukkan pengapan apeks yang sangat baik berbanding selepas 7 hari terutamanya pada tahap 3 mm ke atas dari apeks ($p<0.05$). Kesimpulannya, penyediaan ruang tiang sebaik selepas pengobturatan memberikan pengapan apeks yang lebih baik berbanding 7 hari kemudian tanpa dipengaruhi oleh teknik pengobturatan.

Kata kunci: Pemasangan lateral sejuk; pengapan apikal; penyediaan ruang tiang; satu kon

INTRODUCTION

The restoration of endodontically treated teeth is equally important as the endodontic treatment itself (Tronstad et al. 2000). The clinician should evaluate the restorability of the tooth prior to endodontic treatment to ensure that the tooth is restorable and to decide on the type of coronal restoration suitable for the tooth. The restoration of endodontically treated tooth can be challenging as most of these teeth

have limited amount of tooth structure (Cheung 2005). With the increasing popularity of the nickel titanium rotary canal preparation techniques to achieve a pre-determined prepared canal shape, several obturation methods have been introduced to complement these techniques such as single cone obturation for canals prepared with Dentsply's ProTaper system. The single cone obturation technique is widely practiced due to its simplicity following cleaning

and shaping with greater taper files (Inan et al. 2009). However, the cold lateral condensation technique is still commonly used as it is versatile without compromising the objectives of obturation (Glickman & Walton 2009).

When endodontically-treated teeth have limited remaining tooth structure, a post is required to retain the core for definitive restorations such as crown (Tasdemir et al. 2009). Several studies have shown that root canal leakage occurred when only 2 or 3 mm of GP is retained apically whereas; little or no leakage occurred when more than 4 mm of apical GP remained (Galen & Mueller 1998; Mattison et al. 1984; Metzger et al. 2000; Ricketts et al. 2005; Zmener 1980). Hence at least 5 mm of apical gutta-percha should remain in the root canal to preserve the apical seal and to reduce the risk of apical leakage. Removal of the root canal filling for post preparation was frequently done at a subsequent visit by a different clinician such as a restorative dentist or prosthodontist rather than an endodontist (Grecca et al. 2009). For this reason, this study was conducted to evaluate the apical sealing ability of single cone obturation and cold lateral condensation obturation after post space preparation at different time interval.

MATERIALS AND METHODS

Ethical approval was obtained from the Research Ethics Committee, Universiti Kebangsaan Malaysia (UKM) DD/2011/005(2).

A total of 120 extracted human maxillary premolars with single root canal and closed apices were selected for this study. The teeth which had root caries, structural defects, open apices and root fracture were excluded from the study. Radiographs were taken to ensure only teeth with single root canal were included in this study. The teeth were decoronated at the cemento-enamel junction and stored in normal saline until used. All teeth were prepared using a standard protocol describes below except for the canal preparation and obturation stages.

Prior to the canal preparation, the root canal of each specimen was irrigated with 5 mL 2.5% sodium hypochlorite (NaOCl) (Clorox Company, USA) and explored with a size 10 K-file (Dentsply/Maillefer, Ballaigues, Switzerland) to ensure canal patency. The canal lengths were measured by placing a size 15 K-file (Dentsply/Maillefer, Ballaigues, Switzerland) into each canal until the tip could be seen through the apical foramen. The working length was established at 1 mm short of the apex. The root canals were irrigated with 5 mL of 2.5% NaOCl after each instrument. Canal patency was maintained with recapitulation using a size 10 K-file. Lubricant was used throughout the canal preparation procedure (RC-Prep™, Premier GmbH, Hanover, Germany). Before obturation, all specimens were irrigated with 5 mL of 17% ethylenediaminetetracetic acid solution (Pupldent Corp., Watertown, USA) for 60 s followed by 5 mL of 2.5% NaOCl for 60 s to remove the smear layer. Finally, the root canals were dried with paper points (Dentsply/Maillefer, Ballaigues, Switzerland).

ROOT CANAL PREPARATION AND OBTURATION

The teeth were randomly assigned into 2 experimental groups ($n=50$) which received different root canal preparation and obturation techniques: Group A-hand ProTaper NiTi system (Dentsply/Maillefer, Ballaigues, Switzerland) and obturated using the single cone technique with ProTaper Universal gutta percha point (Dentsply/Maillefer, Ballaigues, Switzerland) and Group B-modified double-flared technique (Saunders & Saunders 1994) using stainless steel K-files (Dentsply/Maillefer, Ballaigues, Switzerland) and obturated with the cold lateral condensation technique. The ProTaper NiTi hand files system was used according to the manufacturer's protocol. The root canals were obturated using single gutta percha cone (SC) corresponding to the last file size used in canal preparation and coated with AH Plus sealer (Dentsply De Trey GmbH, Germany). The SC was seated at the pre-determined working length. Buccolingual radiograph was obtained to evaluate the quality of the root filling, especially homogeneity and apical extension. Coronal excess material was removed using Touch 'n Heat (SybronEndo, Collins, California USA).

For group B, the root canals were prepared with modified double-flared technique using K-files (Dentsply/Maillefer, Ballaigues, Switzerland) which involves coronal flaring followed by working length determination and apical preparation. Gates-Glidden burs (Dentsply/Maillefer, Ballaigues, Switzerland) (sizes 1-3) at 1,500 rpm were used to flare the coronal part of the canal. After the determination of the master apical file (MAF), the apical third of the canal was flared with K-files (sizes 25-50) using step back with 1 mm increment. The root canals were obturated using cold lateral condensation (CLC) technique with master GP (Dentsply/Maillefer, Ballaigues, Switzerland) corresponding to the MAF lightly coated with AH Plus sealer. A size B finger spreader (Dentsply/Maillefer, Ballaigues, Switzerland) was used for this technique. Medium Fine accessory GP cone coated with a thin layer of sealer was placed in the space created by the spreader. Coronal excess GP was removed with Touch 'n Heat and then condensed in the apical direction using endodontic pluggers (HuFriedy, Germany).

Control Groups Ten teeth were randomly selected from each group for the positive control group which were instrumented but not obturated ($n=5$) and root canals that were obturated but did not undergo post preparation for negative control group ($n=5$).

Post Space Preparation The teeth in Groups A and B were further divided into two subgroups based on the timing of its post space preparation: Ai- immediate post space preparation; Ad- Post space was prepared 7 days after obturation; Bi- immediate post space preparation and Bd- Post space was prepared 7 days after obturation. The root fillings were reduced to a distance 5 mm from the working length using Gates Glidden burs and Touch 'n Heat. Buccolingual periapical radiograph was taken

to ensure sufficient removal of GP. The post space was prepared using the Parapost® XP™ System (Coltène/Whaledent, Konstanz, Germany) and the size chosen according to the cross-sectional diameter of the prepared canal. The specimens for delayed post space preparation were wrapped in moistened gauze to assure 100% humidity and stored individually in a sealed container at 37°C for 7 days to allow for complete setting of the sealer.

Dye Leakage Test The external surfaces of all roots were rendered waterproof by applying two layers of nail varnish except on the apical foramen. The root surfaces of the negative controls were entirely coated with two layers of nail polish including the apical foramen, to test the impermeability of nail polish to methylene blue dye. The specimens were then immersed in an aqueous solution of 2% methylene blue dye, pH 7 in individual container. All specimens were incubated at 37°C for 72 h. At the end of the incubation period, the specimens were rinsed under running tap water and dried using paper towel. The nail polish was then removed with a scalpel. Dye penetration was assessed by cross-section technique. To facilitate manipulation and to produce standardized cuts each sample was embedded in silicone putty. Sectioning was done using 0.35 μm fine diamond Isomet® slow speed saw machine (Buehler, Illinois, USA). Each tooth was then sectioned horizontally at 1 mm intervals starting at the apical limit of the preparation and ascending apico-coronally to a total of 6 mm. The sections were evaluated for dye penetration using dissecting microscope (Leica® ZOOM 2000™, Leica Microsystems, Switzerland).

Assessment of Dye Leakage The coronal surface of each consecutive section was photographed using Alicona

InfiniteFocus microscope system (Alicona GmbH, Austria). Dye penetration was determined and the level at which the penetration occurs were recorded. All the readings were recorded by one single operator.

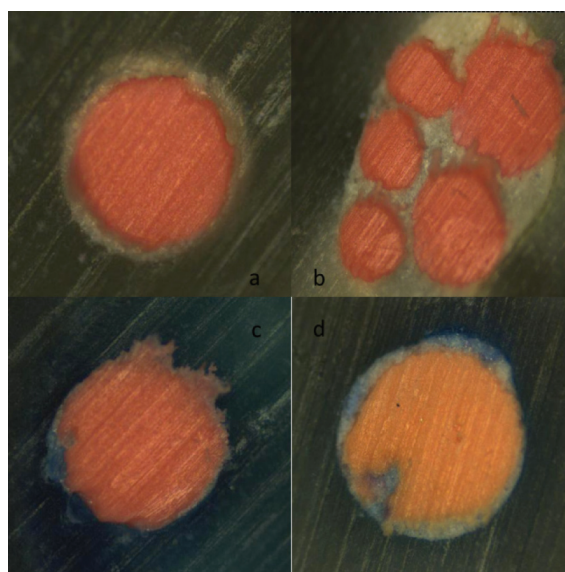
Statistical Analysis The apical seal were analyzed using the frequency and Pearson chi-square test at each observation level at 1, 2, 3, 4, 5 and 6 mm from the apical limit of the preparation with ($p < 0.05$) by using SPSS software, version 19.

RESULTS

No dye penetration was seen in all negative control groups whereas maximum leakage was demonstrated for all positive control groups (Figure 1).

The frequency of dye penetration surfaces were calculated for all slices at 1, 2, 3, 4, 5 and 6 mm from the apical region in each group of 50 samples. There was no statistically significant result in each section when comparing the two obturation techniques at each level ($p > 0.05$) except at the 2 mm section whereby the CLC group shows more leakage than single cone ($p < 0.05$). Nevertheless, both techniques displayed greatest decrease in dye penetration (increase of frequency of no leakages) when the apical distance was between 4 mm and 6 mm from the apex (Figure 2). For comparison between timing of post space preparation, each observation level showed statistically significant result ($p < 0.05$). Frequency analysis shows immediate post preparation demonstrated higher percentage of no leakages compared with delayed post preparation (Figure 2).

Evaluation of the dye penetration revealed that there was no statistically significant difference in dye



SC-single cone, LC-lateral condensation

FIGURE 1. (a) SC with no dye penetration, (b) LC with no dye penetration, (c) SC with dye penetration and (d) LC with dye penetration

penetration between the two groups. However, single cone obturation technique shows better seal at the apical 3 mm of the canal when compared with cold lateral condensation technique. As the sections ascend coronally, both groups' showed almost similar results in dye penetration (Figure 2).

DISCUSSION

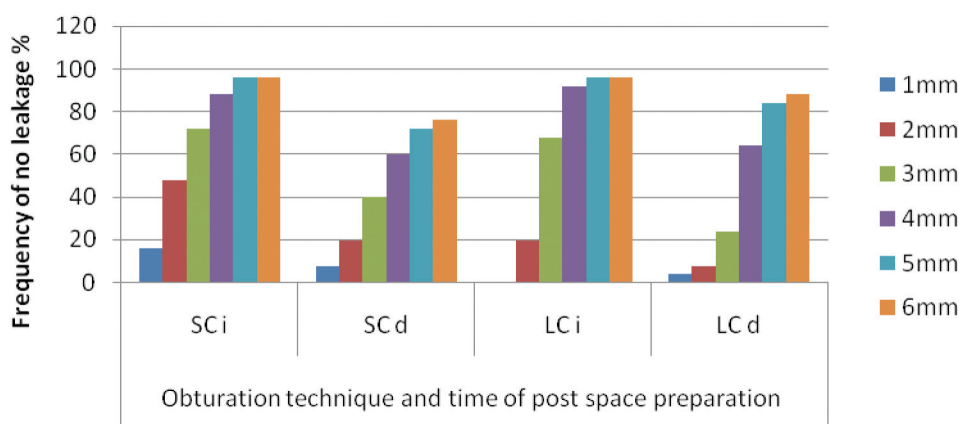
Most endodontically treated teeth that have inadequate remaining tooth structure will necessitate the placement of crown with or without post and core. When the placement of post is required, preservation of the apical seal is important to ensure the success of the endodontic treatment (Grecca et al. 2009). Failure to maintain and preserve the apical seal may cause treatment failure as pathways may be created for bacterial invasion which would result in re-infection of the root canal system and ingress of bacterial by-products or toxin into the periapical area (Ali & Ibraheem 2011).

In this study, the teeth were divided into two groups depending on the root canal preparation technique. One group was prepared using the hand ProTaper® system and the other using modified double-flared technique. The latter technique is widely used and has been proven to be one of the most versatile techniques being practice worldwide (Glickman & Walton 2009). The hand ProTaper system demonstrated reduction in the risk of procedural error, easier to learn, flexible and requires shorter treatment time as the number of files used to complete the canal preparation is fewer (Ruddle 2005). The obturation technique of the prepared canal depends on the canal size and its preparation methods. For the ProTaper system, obturation with a single ProTaper GP cone was recommended as the cone matches the geometry of the ProTaper file, thus, it should conform to the shape and size of the prepared canal with minimal gaps between the cone and canal walls (Wilson & Baumgartner 2003). Some of the advantages of using

single cone obturation technique are acceleration of the obturation procedure; minimal pressure applied on the canal walls and reduction in the gap between the canal walls and eliminates the use of multiple cones (Wilson & Baumgartner 2003). However, one of the limitations of the hand ProTaper system is that its usage may be limited by the root canal size as the largest file size available may not be adequate for the larger canals hence it necessitate the use of conventional crown down technique.

Obturation using cold lateral condensation (CLC) technique is usually used in root canals prepared with modified double-flared technique as the canal shape is usually of less taper and smaller in diameter. With the CLC technique, multiple accessory GP cones are used together with a master GP cone to achieve complete obturation of the prepared root canal space and to ensure that the canal is free of voids. The result of our study showed that the obturation technique does not significantly influence the apical seal of the root treated teeth after post space preparation. The data were consistent with a previous study which showed that single ProTaper GP cone and CLC technique showed similar sealing effect against microleakage (Yilmaz et al. 2009). Another study showed that there is no statistically significant difference between the CLC and thermoplastisized GP compaction technique on sealing ability following post space preparation (Rahimi et al. 2010). Our result also showed that at the 2 mm section, there was significant apical leakage in the CLC group compared with single cone group ($p < 0.05$). This suggested that either insertion of the finger spreader to the working length broke the seal at the apex and caused dye penetration or the accessory cone failed to completely fill the space created by the finger spreader or too much sealer concentrated at the apical 2 mm area which could have led to disruption of the apical seal.

During post space preparation stage, the coronal root filling is removed leaving a minimum of 5 mm of root filling apically as previous studies have shown that apical



SCi – single cone, immediate; LCi – lateral condensation, immediate; SCd – single cone, delayed; LCd – lateral condensation; delayed

FIGURE 2. The frequency of no leakage between SC and LC obturation technique at different time interval

leakage was significantly reduced when more than 4 mm of GP remained in the apical third of the root canal (Gallen & Mueller 1998; Mattison et al. 1984; Metzger et al. 2000; Ricketts et al. 2005; Zmener 1980). The post space is usually prepared either immediately or several days after obturation depending on who will place the coronal restoration (Sadeghi & Kangarloo 2008). The integrity of the remaining root filling may depend on several factors such as techniques and instruments used for removing the gutta percha (Ali & Ibraheem 2011; Shahi & Hoseini 2007), endodontic obturation techniques (Aydemir et al. 2009; Sadeghi & Kangarloo 2008), type of sealer used (Aydemir et al. 2009) and timing of removal of root filling material (Sadeghi & Kangarloo 2008; Shahi & Hoseini 2007).

In this study, the timing of post space preparation immediately after obturation shows significantly less leakage than the delayed groups especially at the apical 3 mm from the apex for both obturation technique ($p < 0.05$) which was consistent with the result of a previous study (Sandeghi & Kangarloo 2008). It is hypothesized that immediate post space preparation allows the sealer to set without introducing micro-fracture or disrupting the bond at the sealer interface as the sealer is still within its working time (Sandeghi & Kangarloo 2008). In addition, immediate GP removal by the endodontist will preserve the aseptic condition thus reducing the risk of re-infection of the root canal space (Grecca et al. 2009). Immediate GP removal also reduces the risk of procedural error such as loss of reference point and perforation of the canal walls as the operator has great familiarity with the root canal morphology and its working length (Ricketts et al. 2005). Furthermore, immediate post preparation creates less 'pulling' effect towards the apical GP because the sealer is not completely set, thus reducing the risk of apical leakage (Ricketts et al. 2005). However, contradictory to our results, several studies have shown that the timing of post space preparation does not affect the apical seal but the quality of the root canal filling plays an important role in maintaining the integrity of the apical seal during post space preparation (Aydemir et al. 2009; Grecca et al. 2009). They concluded that quality of the root canal filling was important to maintain the integrity of the apical seal during post space preparation. From the result of the present study, the single cone obturation technique is recommended in immediate post space preparation cases and the cold lateral condensation is used when post preparation is postponed to a later date.

CONCLUSION

Single cone and cold lateral obturation techniques demonstrate similar outcomes in terms of apical seal. However, immediate post space preparation provides significantly better apical seal.

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